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Iron-based Superconductivity, Multi-orbital Correlations and The Tale of d+d Pairing

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Strongly correlated electron systems often show bad-metal behavior, as operationally specified in terms of a resistivity at room temperature that reaches or exceeds the Mott-Ioffe-Regel limit. Iron-based superconductors present a striking case study. Their bad metallicity implicates orbital-selective electron correlations and, at the same time, leads to short-range frustrated spin-exchange interactions. These features, in turn, have important consequences for the superconducting pairing. One is a quasi-degeneracy in various pairing channels, and another is the emergence of the so-called orbital-selective pairing [1]. These issues will be introduced in the talk. I'll then go on to present a unusual pairing state dubbed "d+d" pairing [2,3], and describe how its matrix structure in the orbital space has a surprising formal analogue with its spin-space counterpart in the B-phase of the ^{3}He superfluid [2]. I'll make the case that the d+d state describes certain iron-selenide superconductors (that are among the group of highest Tc iron-based superconductors). In a twist befitting the aspired universal understanding across strongly correlated superconductors, the d+d pairing state turns out [2] to also solve a serious new riddle that recently arose in the heavy fermion system CeCu2Si2, the very first unconventional superconductor ever discovered.

[1] Q. Si, R. Yu and E. Abrahams, Nature Reviews Materials 1, 16017 (2016).

[2] E. M. Nica and Q. Si, Npj Quantum Materials 6, 3 (2021).

[3] E. M. Nica, R. Yu, and Q. Si, Npj Quantum Materials 2, 24 (2017).

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